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ABSTRACT

This paper describes the use of individualized instruction concepts in courses on structural design in undergraduate engineering programs. Areas covered include the distribution of time, unit packages, laboratory, and grading. Specific features discussed include class discussion, programmed problems, and summary units. Outcomes of such courses have been: (1) more effective learning of course materials by students, (2) greater efficiency in time spent by teachers and students, (3) better student-teacher relationships, (4) better understanding of course objectives by teachers, and (5) immediate feedback to students and teachers. It is suggested that individualized instruction would be useful in continuing education for professional engineers. (DAG)

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SRUCTURAL DESIGN WITH INDIVIDUALIZED INSTRUCTION

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IR 005 168

STRUCTURAL DESIGN WITH INDIVIDUALIZED INSTRUCTION

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INTRODUCTION

The writers first exposure to Individualized Instruction as a learning method was during the 1970 Annual Meeting of the American Society for Engineering Education. Gordon Flammer delivered a paper, "Lets Make Learning the Constant and Time the Variable." Not only was the title appealing but the concept ignited a teaching change. Since 1970 Individualized Instruction (heareafter referred to as I.I.) has been used in eight different courses which the writer teaches. Many modifications have been made as a result of student feedback, personal reactions and contacts with others using I.I.

Four papers have been written relating experiences with a particular phase of I.I. All of these have been through the American Society for Engineering Education.

1. Experiences with Individualized Instruction
   1971 ASEE Annual Meeting
2. Unit Modules in Mechanics
   1973 North Central Section

3. Grading With Individualized Instruction
   1974 ERM Division
4. Cost Effectiveness of Individualized Instruction
   1976 North Central Section

This present presentation is limited to the five courses in the structural design sequence with a particular emphasis on the two courses in Reinforced Concrete Design.

HOW THE COURSES ARE TAUGHT

Reinforced Concrete Design consists of two courses taken in consecutive quarters by Civil Engineering Seniors. One is a four credit course and the second is three credits.

This writer emphasizes five principles as characterising I.I., namely:

Small Steps
Active Response
Immediate Confirmation
Self Paced
Student Tested

The first unit in the course is titled I.I. and is used to acquaint the student with the learning method and to get him started properly.

TIME DISTRIBUTION

The four credit courses as described in the university catalog indicates three-one hour lectures and a three hour lab per week. Three class meetings are held each week but instead of one three hour lab, the instructor is available in the lab four afternoons a week for two hours each day. The class time is used for discussions and the lab time for the students to show mastery of the units.

TEXTBOOK

For the two courses in Concrete the textbook used is "Reinforced Concrete Design" by Wang and Salmon.

UNIT PACKAGES

Unit Packages have been developed for each unit. These consist of:

RATIONALE

SPECIFIC OBJECTIVES

LEARNING ACTIVITIES

- INPUT
- PRACTICE
- FEEDBACK

The learning activities in the unit packages follow the textbook although some material is deleted and the sequence is occasionally altered. The INPUT generally involves reading the text. PRACTICE is where the students answer questions or work problems. In the FEEDBACK the instructor provides his answers to the questions or the problems.

Students are free to utilize the unit packages to their benefit. That is, some will take Unit 4 only when Unit 3 has been mastered. Others will take all the units at the start of the quarter. A few will master the units out of sequence, that is, they may complete Unit 6 before Unit 4.

LABORATORY

When a student feels he understands a unit he appears in the lab and requests an objective measure (or test) for a particular unit. He then works it in the lab and when complete brings it to the instructor for evaluation. If all the problems are correct

he is given a grade of 2 which indicates the work is perfect and he goes on to the next unit.

If there are some errors in the objective measure, the instructor has a decision to make which is dependent upon not only the type of mistake but also upon the individual student. If the objective measure contains no lapses in theory but only math errors, the instructor usually gives the student a grade of 1 and allows him to proceed to the next unit. On some problems the numbers are a significant part of the solution and the correct answer is important. In that case the instructor will have the student make the numerical corrections. Some students consistently make numerical errors. If this pattern develops during the quarter, the instructor becomes more insistent that those students always correct their errors.

When a student indicates a blunder in his interpretation of the theory, the instructor either makes an explanation or refers the student back to the textbook or another reference and marks that objective measure an0. After this student has done some additional work he again appears in the lab and is given a different objective measure for the same unit and the process continues. There are usually four different objective measures for each unit.

The instructors grade book becomes filled with 0's, 1's and 2's as well as the date for each grade. Probably 75% of the grades are 1's indicating some numerical errors but no lapses in theory. It should be pointed out that there are usually three specific objectives for each unit. Hence, there are generally three problems on the objective measure. Most of these problems require several steps in the numerical calculations. To obtain a 2,

the student has to avoid mathematical mistakes in all three problems.

GRADING

The possible grades in these courses are A, B, C, D, I, and F where the I is an incomplete. If the student completes all units with a grade of 1 or 2 he has earned a C.

To obtain a B, he makes an evaluation of his own and another solution to a series of open-ended design problems. Most of the problems on the objective measures are closed-ended problems meaning there is only one correct answer. Some problems (about 8 in the quarter) are open-ended, meaning the student is free to choose some variables. For example, only the load and the span might be prescribed in a beam design. The student can select the supports, material properties and cross section. There would be many acceptable designs. In the B level work then, the students compare and evaluate different open-ended designs.

The A level work is the development of a design approach to an open-ended design problem. Here the emphasis is not on the numerical design since the student has already demonstrated mastery of this phase, but rather a decision making approach is stressed. The significant steps in this process are:

Problem Definition

Constraints

Alternate Solutions

Analysis

Evaluation

Bloom's Taxonomy of Educational Objectives is used to coordinate the level of learning with the grading system. C level work is knowledge and comprehension, B work is application and analysis

and A work is synthesis and evaluation.

UNIQUE PHASIS OF THIS APPLICATION OF INDIVIDUALIZED INSTRUCTION

There have been many different applications of the Individualized Instruction method of learning. Features which appear to be unique in this description of structural design are:

Class Discussions

Programmed Problems

Summary Unit

Grading

Laboratory

Ohio Northern University has a few unique characteristics which should be mentioned. There is no graduate program in Engineering. The number of students enrolled in each course of Reinforced Concrete Design is usually about 15. There is no attempt on the part of the writer to suggest that what has worked in a particular situation would be successful in every academic situation.

CLASS DISCUSSIONS

It appears that many instructors who adopt I.I. eliminate or greatly minimize the number of regular class meetings. For the courses described in this paper there are three classes a week for the 4 credit course and two classes a week for the 3 credit course.

These discussions are on a firm schedule. For example, on January 30, the topic will be Footings. Students know the schedule in advance. Those who have already completed this unit still have something to learn and can actively participate in the dis-

cussion. For those students who have not reached this unit, the discussion serves as an indication of what to expect.

Classroom discussions consist of motivating lectures, typical design problems, questions and answers as well as case studies. This writer believes that the lecture still has a place in the learning process, even in an I.I. type of learning. However, the intent of the lectures (which are usually about 15 minutes in duration) ~~are~~ is not to transmit information but rather to motivate the student to learn on his own.

Since many structural design problems have more than one method of attack, the writer feels an obligation to share with the students his own design philosophy. The discussions during this part of the class time are helpful to the instructor in diagnosing individual student problems.

PROGRAMMED PROBLEMS

The instructor has developed a series of programmed problems for most units in these courses. These are not programmed learning in the usual use of the phrase, but rather a detailed step-by-step approach through a design problem. For example, in the unit of torsion the programmed problem has thirty-six different steps where the student completes a calculation in each step and checks to see if it is correct. Student response to these programmed problems has been very favorable.

SUMMARY UNIT

In each of the courses there is a summary unit which attempts to tie the individual units together. Usually this consists of one design problem. For example, the design of a concrete build-

ing to manufacture cheese which requires 40000 square feet of floor space.

The student first selects the design parameters such as material strengths, structural system, bay spacing and supports. He submits these parameters along with the reasons for the selections to the instructor. When this preliminary phase is considered acceptable, the instructor asks the student to complete the design for typical members, such as footing, column, beam and slab. On the basis of the typical members the student then estimates the total cost of this design for his final report.

This summary unit has been added in recent revisions of this learning method. It is felt to be beneficial to the students.

GRADING

The grading method used has been described earlier. It is believed to be unique because of the relationship between learning level and the grade received. Performance on the final exam has no effect upon the student's grade. The grade is solely dependent upon the units completed at the end of the quarter. Students must take the final exam but it is used by the instructor to measure the effectiveness of this learning method.

It is possible to look back on student performance when writing letters of recommendation and to say not just that a particular student received an A in a course but rather that this student demonstrated mastery of the fundamentals of concrete desing (C grade), showed an ability in application and analysis (B grade) and indicated the ability to synthesize a problem and to make an evaluation (A grade).

Student reponse is typically very positive when they realize there is little or no pressure on them during testing or exams.

In addition, they are enthusiastic to the B level work, that is the evaluation of open-ended design problems.

LABORATORY

The grading done in the laboratory has been described in an earlier section. It is the individual type of grading which is unique. The instructor firmly believes that he has become a diagnostician of learning problems. It is a simple matter to grade an objective measure as acceptable or not, however, what is helpful for the student's learning is to identify for him why he is getting the problem wrong. This phase of I.I. has given the instructor great personal satisfaction.

CONCLUSIONS

As a result of several application of I.I. with Reinforced Concrete Design, the following conclusions can be reached:

1. This approach is effective.
2. The approach is not efficient.
3. The instructor knows the student better.
4. The instructor has a better understanding of the courses.
5. Immediate feedback is the biggest advantage of I.I.
6. Continuing education offers great possibilities for I.I.

EFFECTIVENESS

Based on student responses to questionnaires and on student performance on the final exams, this method of learning is academically effective. The students indicate the goals of the course are reasonably well satisfied. Students have demonstrated an understanding of the fundamentals of Reinforced Concrete Design. Conversations with graduates who are doing work in concrete design indicate that they are competitive with graduates from other schools.

EFFICIENCY

It is an undeniable fact that the courses as now taught take more time on the part of the instructor than would a traditional course. The instructor has more contact time with the students. In addition, some time is needed to revise the units for the following year. There is, of course, the time initially needed to develop the unit packages. Thus, this application of I.I. is not cost efficient.

It would be possible to change the picture, that is classroom meetings could be eliminated which would give the instructor less contact time and would reduce the "cost" of the course. However, it is the instructor's opinion that this would reduce the academic effectiveness. This is one advantage of the instructor being the department chairman, he can decide which has the higher priority, academic effectiveness or economic efficiency.

KNOWING THE STUDENTS BETTER

Knowing the students better goes beyond the grading of objective measures. As a result of continual contact and feedback with students, the instructor is in a position to understand them not as students in Reinforced Concrete, but rather as individuals. This is important, at least at Ohio Northern, since there is a committed concern with the education of the whole man.

BETTER UNDERSTANDING OF THE COURSES

One of the big advantages to the instructor of I.I. has been the development of a better understanding of the field of Reinforced Concrete Design. This is brought about by the creation of the individual unit packages, particularly listing the specific objectives and writing the learning activities. If nothing else

were done, this would be time well spent for the instructor.

IMMEDIATE FEEDBACK

The immediate feedback is important to both the student and the instructor. It is essential for the student to have confirmation as soon as possible concerning whether his approach is correct or incorrect. The longer he has to wait, the greater the confusion that can develop. This is probably more crucial for the weaker student than for the top student. From the instructor's position, it is important to identify as early as possible where the student has gone astray in his approach and to get him back on the right track. That is, if a student makes a mistake and it is identified and corrected immediately and the correct approach instilled in the student's mind, he will have a better chance of retaining the correct approach.

CONTINUING EDUCATION

Current practice in the field of Reinforced Concrete Design is to have a revised building code about every decade. Changes are sometimes significant. The development of new units of material with an I.I. format would allow practicing engineers to maintain their competency. It is possible that the engineering profession will require practitioners to demonstrate some form of continuing education in order to maintain their registration. This could result in a need for I.I. materials in structural design on a very large scale.

QUESTIONS AND ANSWERS

Q 1. What are the other courses in the structural design sequence?

A 1. There are two courses in Steel Design and one course titled

A 1. (continued)

Design of Structural Systems in addition to the two courses in Reinforced Concrete.

Q 2. How many units compose the concrete courses?

A 2. In the four credit course there are 13 and in the three credit course, 9.

Q 3. What are the titles of the units for the first course in concrete?

A 3. Individualized Instruction
Higher Levels of Learning
Analysis
Strength Design
Beams and Girders
Shear
Materials
Columns
Footings
Development of Reinforcement
Walls
Torsion
Summary

Q 4. How do students react to the textbook?

A 4. Rather negatively. It seems that a better than average text is necessary with I.I.

Q 5. What has been the grade distribution?

A 5.

In 1975-76	A	B	C	F
Reinforced Concrete 1 (winter)	8	4	0	0
Reinforced Concrete 2 (spring)	5	0	6	1

Q 6. How is the effectiveness measured?

A 6. Questionnaires are distributed to the students. An interest questionnaire at the start and again at the end of the quarter measures the change in interest. Students are also asked how well the course objectives have been met at the end of the quarter. In addition, performance on the final exam measures the overall effectiveness.

Q 7. How do students perform on the final exam?

A 7. In 1975-76 the grade distribution of the final was:

over 90%	6
80-89%	3
70-79%	2
60-69%	1
below 60%	0

Their pride in scoring as well as they can is surprising since they know that the performance has no effect on the grade.

Q 8. Are tutors used in the lab?

A 8. Not in the structural design courses simply because the students are seniors and there are no students in school who have taken the courses. The use of tutors in earlier courses in I.I. such as engineering mechanics has been very successful. The instructor will experiment in the winter quarter of 1976-77 with a peer tutor, that is a tutor or grader who is enrolled in the course but who has completed units which classmates are still working on.

Q 9. Is class attendance required?

A 9. No. As an average about 90% of the class attends regularly.

A 9. (continued)

Typically, the 10% who miss occasionally are those who are behind in the units.

Q 10. Is procrastination a problem?

A 10. Not usually. All students have had at least one previous course in I.I. with the instructor and know what to expect.

Q 11. Do students spend more time on I.I. courses as compared to traditional courses of the same credit?

A 11. The experience has been that students do spend more time but they don't seem to complain. They apparently feel that they learn more.

Q 12. What improvements could be made in the Reinforced Concrete Courses?

A 12. Clarify vague phrases in the unit packages. Provide for more alternatives to learning for particular students.

Q 13. What has been the general reaction of students?

A 13. Probably half the students are very positive in their responses on questionnaires. Perhaps one third are neutral. Occasionally there is a student who is negative about the approach.

Q 14. What has been the general reaction of colleagues?

A 14. Some have adopted a form of I.I. in their own courses. The majority are not particularly interested. A few feel that I.I. makes learning too easy.